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EXPERIMENT STATION

U. S. DEPARTMENT OF AGRICULTURE - FOREST SERVICE

CENTRAL STATES FOREST EXPERIMENT STATION R. D. LANE, DIRECTOR

111 OLD FEDERAL BUILDING, COLUMBUS, OHIO

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1960 Annual Report
Central States Forest Experiment Station
U.S. Department of Agriculture, Forest Service

Page 6.--Last paragraph, second sentence should begin:
"Nearly half of the trees are classified..."

Figure 2:

Years in key are reversed; dotted line should be 1959,
dotted-dashed line should be 1947.

Page 7.--Substitute the following for the next to the last paragraph:
"Sawtimber grew 318.8 million board feet per year, an average
of less than 74 board feet per acre. In sawtimber stands the
average increase was 98 board feet per acre but only 1/3 of
the sawtimber growth occurred in sawtimber stands. The re-
mainder is scattered through other stands."

Page 51.--Last sentence should begin:
"Describes a promising method of recording..."



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1960 IN BRIEF

This year our annual report brings to you the highlights of research we completed in 1960. We have concentrated more on the present this time and less on the past and future. As a result our report is, we hope, informative and it is brief—you can read it all in about half an hour. You are cordially invited to consult our publications, listed at the end of this report, or call on us if you desire more information about either the results summarized here or our research program in general. And we would appreciate having your comments and suggestions on the kinds of future annual reports you would like to receive from us.

Research Programs

No striking changes have occurred in our research this year. We continue to work for the solution of major regional problems that are obstacles to full multiple use management of our forest resources. But we are shifting emphasis to greater depth in research and to solution of the more basic aspects of regional problems without curtailing valuable applied research. These changes will come slowly because they depend upon many factors: Upon more intensive scientific training and marshaling specialized research talents; upon developing modern research facilities such as our new forest insects and disease laboratories at Delaware, Ohio; upon increasing funds for new research; and upon utilizing resources released as going studies are completed.

During 1960 we completed 22 individual studies and started 34 new ones, leaving a balance of more than 250 active studies. These active studies are divided among forest, range, and watershed management; control of fire, insects, and diseases; economics and marketing; and forest products utilization.

Our research is essentially complete in the forestation of coal-stripped land and in methods of planting conifers. Also, we have nearly completed our work in the management of natural coniferous stands. Thus, a part of our forest management research resources is becoming available for new work. In the future we will devote more attention to hardwood problems such as methods of establishing plantations of high-value species, evaluation of forest soils and sites, stand density, and tree improvement.

During the next few years forest fire research will emphasize local fuels, fire prevention, and prescribed burning techniques.

Watershed research will continue to be directed toward discovering the basic principles of subsoil water movement and developing methods of protecting, improving, and managing forested watersheds.

Our range research will be concerned with improving, maintaining, and efficiently utilizing forage; with land-use classification; with the taxonomy, ecology, and physiology of range plants; and with the measurement and evaluation of forage.

Research in forest economics will concentrate upon lumber-manufacturing costs, opportunities for expanding primary wood-using industries, alternative forest investment opportunities, and the productivity of small forests.

In forest utilization research we are emphasizing hardwood log and tree quality, processing of hardwood logs and lumber, and the use of hardwoods for farm and outdoor recreation structures.

The first major building of the planned installation for our forest disease and insect research at Delaware, Ohio was completed and occupied in May 1960. This new facility enhances significantly our opportunities to contribute to the control of forest pests. We believe our best opportunities are through research in host-pest relations; in viruses, predators, systemics, and antibiotics; and in more specific chemicals that give control without undesirable side effects. The new forest insect and disease laboratories are a vast improvement over our previous research facilities and we are looking forward to completing the entire installation. Especially, we hope the greenhouses can be added in the immediate future.

Recreation resources are becoming increasingly important in the multiple use management of forests in the Central States. Thus, we feel that we should soon undertake research in forest recreation. So that we can readily move into an active program, a preliminary analysis is being made of forest recreation problems and research opportunities that are unique in the Midwest and are not being studied elsewhere.

Research People

In sharp contrast to our research program, striking changes did occur in the Station staff.

Dr. W. G. McGinnies, Director of the Station since 1954, retired after 30 years of government service. Actually, Bill didn't retire—he began a

new career! He now is Director of the Tree Ring Laboratory and Coordinator of the Arid Land Research Program at the University of Arizona in Tucson.

His arrival at the Station 7 years ago heralded an era of growth:

Research in forest diseases and insects was added via re-organization of the Department of Agriculture.

New field offices were established at Berea, Kentucky; Bedford, Indiana; New Philadelphia, Ohio; and Springfield, Missouri.

Forest utilization research was strengthened at Carbondale, Illinois.

The division of watershed management research was added.

The forest insects and disease research laboratories at Delaware, Ohio were conceived, designed, constructed, and occupied.

During the year ten other technical people left the Station—nine started new Forest Service assignments and one went to the armed services. Three transferred to the Forest Products Laboratory—Erwin H. Bulgrin, J. T. Quirk, and John H. Farrell—and two transferred to other experiment stations—David P. Worley to the Rocky Mountain Station and Lawrence W. Hill to the Pacific Southwest Station. Robert F. Buttery moved to Region 5 where he is doing range work. LaMont G. Engle moved to Region 9 to work in the Division of Timber Management, and William D. Buchanan transferred to Region 8 where he is working on forest insects survey and control. David J. Neebe joined the Washington Office Division of Forest Economics and Marketing Research. Calvin F. Bey is on military leave; we hope he will rejoin the Station in 1962.

Nearly as many technical men (nine) joined the Station as left. Richard D. Lane, formerly Assistant Director, Division of Forest Management Research in our Washington Office, succeeded Dr. W. G. McGinnies as Director. Three of our new scientists were selected from the Civil Service Register: James Schroeder, Forest Utilization Research, Carbondale, Illinois; Gayne Erdman, Forest Management Research, Ames, Iowa; and Pierre Hart, Forest Management Research, Berea, Kentucky. Charles Leaphart transferred to our forest disease research laboratory at Delaware, Ohio, from the Intermountain Station, and Fred Berry transferred from the Agricultural Research Service, Beltsville, Maryland, to our Columbia, Missouri, office, where he will conduct research on forest diseases. Errett Conway came to us from the Rocky Mountain Station to assist in our forest utilization service program, and Willis Vogel transferred from the Soil Conservation Service, Dubois, Idaho to our range research project at Springfield, Missouri. One of our former employees, Russell Ryker, completed his advanced study at the University of Missouri and is now located at our Kaskaskia Experimental Forest, Elizabethtown, Illinois.

We continued our efforts in 1960 to provide opportunities for our employees to receive advanced training. Eleven of our scientists were enrolled in formal classes at colleges and universities. Their advanced study ranged from full-time enrollment to participation in special courses such as the Field Institute of Forest Biology sponsored by Duke University.

Our Mathematical Statistician, Chester Jensen, conducted a 3-week training course in statistical methods that was attended by six of our scientists as well as two from other Forest Service offices.

In 1959 we embarked on a training program to help our professional people become better writers. Twenty-two men participated in these week-long writing workshops during 1960. Except for recent recruits, nearly all of our technical people have received this training. We now plan to conduct one workshop a year for new employees and to provide occasional refresher sessions. Robert D. Wray, Station Publications Officer, conducted this training. He is preparing for publication an outline of the training course and an analysis of the results.

Also during 1960, four of our Station Management employees participated in a week-long Fiscal and Operations Training Course conducted by Region 9.

ECONOMICS

During 1960 activities in the Division of Forest Economics included forest survey reinventory in the Eastern Ozarks of Missouri; studies of the relation between timber management practices and types of owners of small forested tracts; studies of the purchase, sales, and business policies of firms engaged in manufacturing lumber products; a regionwide survey of pulpwood production; and timber price reporting.

Eastern Ozarks Timber Inventory Completed

The resurvey of the timber resources of Missouri was begun in January 1958 and completed in November 1960. This report, the first in a new series, provides up-to-date information on the heavily forested Eastern Ozarks Region.

This is the most heavily forested region in Missouri. More than 70 percent (4.3 million acres) of this 14-county area is commercial forest land, which is more than three-fourths privately owned.

The area of commercial forest land bearing sawtimber stands almost doubled since 1947 (fig. 1). Sawtimber now occupies 28 percent of the commercial forest area. Poletimber stands were reduced in area but still

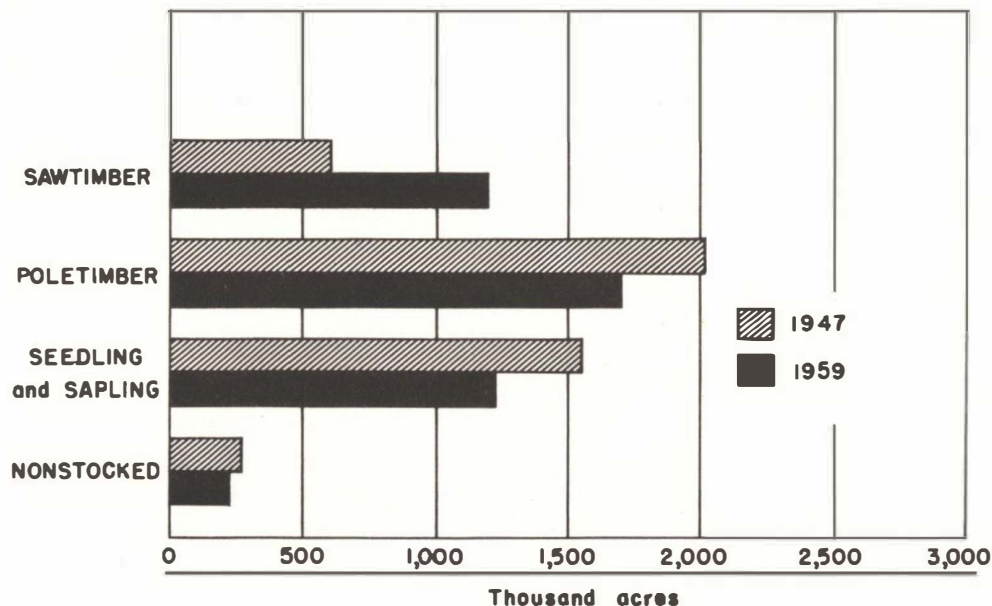


Figure 1.—Changes in commercial forest area from 1947 to 1959 in the Eastern Ozarks of Missouri, by stand-size class.

occupy 39 percent of the commercial forest land. The seedling and sapling and non-stocked stands were both reduced in area and now occupy 28 percent and 5 percent of the commercial forest land respectively.

The pine type has almost doubled in area since 1947, largely because of conversion from the oak-pine type. The pine type now occupies about 5 percent of the commercial forest area while the oak-pine type occupies 11 percent.

Perhaps the most noteworthy change is the increase in growing stock, which now totals 21.6 million cords. Since 1947 it has increased by 5.6 million cords or 3 percent annually (table 1). The volume of growing stock now averages 5 cords or 395 cubic feet per acre. Approximately 59 percent of the volume is in poletimber and the remaining 41 percent is in trees of sawtimber size.

Sawtimber volume has increased by almost 8 percent since 1947 and now totals 3.3 billion board feet (table 2) and averages about 760 board feet per acre.

Tree quality throughout the region is low. The trees are classified as crop and storage trees i.e. those considered as desirable to remain in the stand for at least 10 years. All the rest are poor-risk trees which, because of poor form or other defects, should be removed from the stand. Sawlog material also grades low: Almost 70 percent is Tie and Timber grade, another 22 percent is Grade 3, while only 8 percent is in Grades 1 and 2. However, much of this low log quality is because of size and not cull or defect (fig. 2).

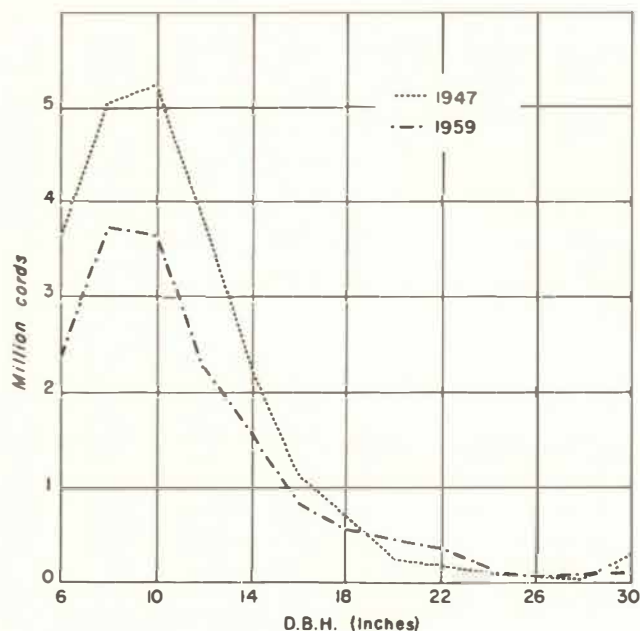


Figure 2.—Distribution of growing-stock volume by tree diameter classes, 1947 and 1959.

Table 1.—Comparison of the 1947 and 1959 growing stock by species group

Species group	1947	1959	Change	
	<u>Thousand cords</u>	<u>Thousand cords</u>	<u>Thousand cords</u>	<u>Percent</u>
Softwoods	1,584.8	3,004.0	+ 1,419.2	+ 89.6
Soft hardwoods	863.3	704.4	- 158.9	- 18.4
Hard hardwoods	13,453.2	17,853.1	+ 4,399.9	+ 32.7
Total	15,901.3	21,561.5	+ 5,660.2	+ 35.6

Table 2.—Comparison of the 1947 and 1959 sawtimber volume on commercial forest land by species group

Species group	1947	1959	Change	
	<u>Million bd. ft.</u>	<u>Million bd. ft.</u>	<u>Million bd. ft.</u>	<u>Percent</u>
Softwoods	310.3	566.1	+ 255.8	+ 82.4
Soft hardwoods	265.3	125.7	- 139.6	- 52.6
Hard hardwoods	2,486.8	2,606.7	+ 119.9	+ 4.8
Total	3,062.4	3,298.5	+ 236.1	+ 7.7

Annual net growth amounted to 1.2 million cords, or 6 percent, pole-sized trees accumulating three-fourths of this.

Sawtimber grew 124.6 million board feet per year, an average of less than 30 board feet per acre. In sawtimber stands the average increase was 55 board feet but only half the sawtimber growth occurred in sawtimber stands. The remainder is scattered through other stands.

The resurvey of the Eastern Ozarks Region of Missouri has revealed that the timber resource of this region is rapidly recovering from an era of mismanagement and has a great potential to become an increasingly important timber source for the future.



Figure 3.—Mechanization has encouraged pulpwood production.

Pulpwood Production Continues to Increase

The annual pulpwood canvass shows a continuing upward trend in pulpwood production and consumption in the Central States (fig. 3) (39)¹. Pulpwood production in 1959 amounted to over 357,000 standard cords, almost 23 percent more than in 1958. Gross value of this timber harvest delivered at the mill amounted to \$4,853,000.

Consumption of pulpwood by the 18 wood-using mills of the Central States amounted to 359,000 cords, an increase of 22 percent over 1958 and comparable with the increase in production.

Ohio produced and consumed about half of the pulpwood.

Remanufacturing Increases Profits

In eastern Kentucky a gradual increase in manufacturing of lumber products beyond the rough lumber stage has increased direct sales by lumber producers and increased the resale price of low-value lumber (55). These improved practices help the development of communities in the heavily forested areas. Each additional step in the manufacturing process increases product value, the investment in plant labor and equipment, and also the returns to the community (54). For example, plants that used about 2 million board feet of timber but which produced only green lumber returned less to the manufacturer and the community than did plants that manufactured air-dried, dressed lumber and associated products (table 3).

Forest-Product Prices in Ohio—1959

Although some forest products and some species showed slight price declines, there was a general increase in the prices paid for Ohio timber products during 1959 (38). Sawlogs showed an average increase of \$4 per thousand board feet over 1958 prices, while commercial veneer logs

¹Numbers in parentheses refer to publications listed on page 43.

used for furniture and similar items were worth about \$13 per thousand board feet more than in 1958. Other product prices remained stable or showed only slight changes.

As a result of the progress made in our price reporting, the Agricultural Marketing Service, the Ohio Division of Forestry, and the Ohio Department of Agriculture have assumed responsibility for future timber price reports and will issue them quarterly.

Small Woodland-Owner Characteristics in Ohio

About 90 percent of Ohio's 5 million acres of forest land is held by 150,000 owners having woodlands less than 500 acres in size.

A recently completed study of some of these owners in selected hill and corn-belt areas of Ohio indicates that few owners had taken positive measures to improve their forest land (fig. 4). Reasons given for owning forest land varied widely (table 4).

The study also shows that only 10 percent of the owners had used public assistance programs available to small forest land owners. The reasons the owners gave for not participating in one of these programs (ACP cost sharing) varied by region (table 5).

Table 3.—Receipts and expenditures: Lumber producers only vs. remanufacturers

Item	Plants producing rough lumber only	Plants doing further processing
	<u>Dollars</u>	<u>Dollars</u>
<u>Expenditures</u>		
Stumpage purchases	35,200	35,200
Payroll	44,500	102,900
Equipment	11,200	41,800
Power	6,000	13,000
Other	7,600	17,000
Total	104,500	209,900
<u>Receipts</u>	123,900	259,600
<u>Margin</u>	19,400	49,600



Figure 4.—(top) In the hill area of Ohio most woodland owners are interested in growing timber; (bottom) in contrast, in the corn-belt area most owners either plan to graze their land or clear it for other purposes.

Table 4.—Purposes of small forest land owners in Ohio

Primary purpose for holding land	Percent of owners	
	Hill country	Cornbelt
Timber growing	76	25
Liquidation	0	10
Recreation	3	3
Residence	14	0
Grazing	0	49
Mineral	4	0
Other	3	13
Total	100	100

Table 5.—Reasons for non-participation in ACP program

Owners' reasons for not using program	Percent of owners	
	Hill country	Cornbelt
Program not available in locality	1	0
Not interested in forestry	9	42
Unaware payments were available	53	29
Lack of time to do work	23	9
Unsympathetic toward subsidies	3	5
Other	11	15
Total	100	100

FIRE

Litter Depth and Weight Studied

Examinations of litter and duff in shortleaf pine (*Pinus echinata* Mill.) stands in Missouri show some reasons for variations in fire intensity observed in that region.

Litter and duff found in sample stands averaged about 11.3 tons (dry weight) per acre and 1.6 inches deep (fig. 5). The average difference in depth of all stands was small, only about 0.8 inch. Occasional deep spots (6 inches) were found around rotting logs and limbs. The litter fraction makes up about one-third of the total dry weight, an average of about 3.9 tons per acre. The amount of litter and duff increased as the basal area of the stand increased.

Stand basal area also affected the rate of accumulation of litter. About 1.7 tons (dry weight) per acre fall each year. The heaviest litter fall (about 60 percent) is from September through November, although there is some each month.

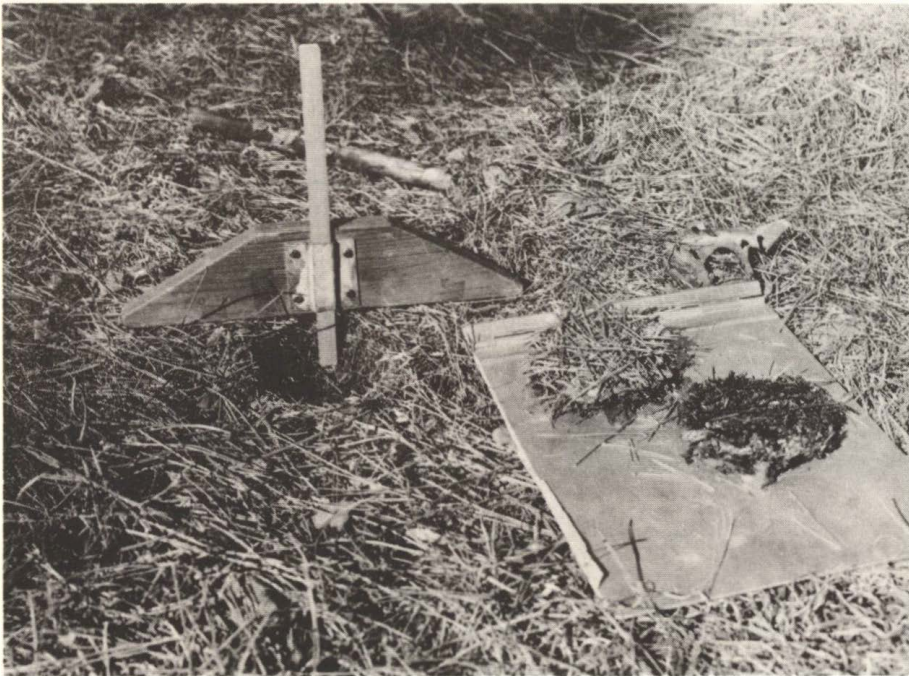


Figure 5.—Measuring depth of litter and duff.

Shortleaf Pine Resprouts After Fire Damage

Planted shortleaf pine can survive after fire injury by producing basal sprouts. Three-year-old planted trees in Missouri showed this capacity after controlled burning in 1959. These trees averaged 3.6 feet in height (some were as tall as 7 feet) and most were top-killed by the fire. Some of the taller trees were only damaged.

During the summer following burning, all trees, except the few (7 percent) smaller ones that were consumed by fire, sprouted (fig. 6). Some of these sprouts died during the summer, however. The larger trees generally had more sprouts, and the sprouts usually were taller. In evaluating fire damage in juvenile shortleaf pine stands, you can expect permanent loss or damage to be greatest on the smaller, less-vigorous trees.

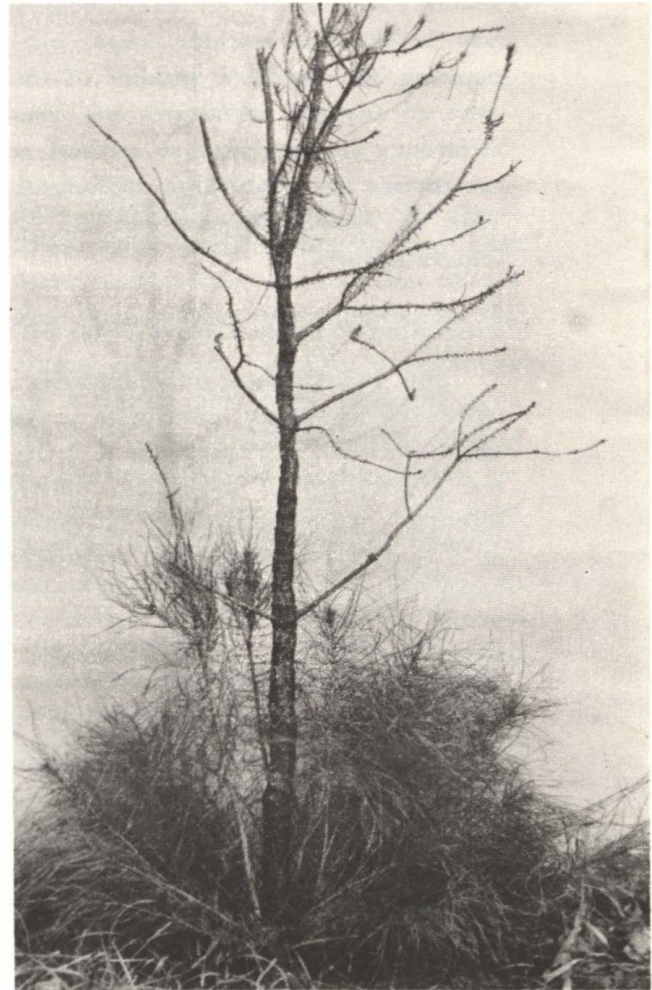


Figure 6.—Young shortleaf pine, top-killed by fire, developing new sprouts.

INSECTS and DISEASE

The Insects and Disease Divisions moved to their new laboratories near Delaware, Ohio in May. The official dedication of the laboratories on October 31, 1960 signified a major step forward in forest insect and disease research. Although moving to and getting settled in the new building was a big job, it was done without a major curtailment of research and reporting activities.

Background for Insect Control

The population of any insect is determined by both the number of offspring produced, and the number that survive adverse influences. Research on control of an insect begins by measuring these influences. This may be done in various ways, but the basic approach consists of estimating the possible number of insects that would be present if there were no adverse influences and comparing this with actual survival. The difference is attributed to natural control. Usually, natural control does not reduce the population sufficiently to prevent insect damage to trees. This is where we must use the suppressing effect of chemical or biological agents.

Irradiation of Black Locust Borer With Cobalt 60

The locust borer (*Megacyllene robiniae* Forst.) is not sufficiently repressed by natural control to prevent extensive damage to black locust trees (*Robinia pseudoacacia* L.) (fig. 7). So we have been investigating the possibility of biological suppression of this insect. One method, releasing males sterilized by radiation, used successfully in the West on a species of cattle fly, was tried in laboratory tests with the locust borer.

The influence of radiation on the sexual activities of the locust borer was experimentally investigated by subjecting male and female beetles to gamma ray emission from Cobalt 60.

Previous observations of the normal mating habits of the locust borer revealed that a male would mate repeatedly with one female, as often as 11 times. One male mated with 11 females a total of 61 times. Viable egg production ranged from 0 to 40 with an average of 20 per female. With treatment rates of 1,000, 5,000, 10,000, and 15,000 roentgens there was no adverse effect on fertility, but a dosage of 15,000 roentgens appears to be the threshold beyond which fecundity might be reduced.

Figure 7.—Severity of locust borer damage seen in peeled black locust.



Elm Bark Beetle Control

A search has been made in recent years for a chemical that could be transported internally in elms (*Ulmus* spp.) and protect the tree from attack by the elm bark beetles (*Scolytus multistriatus* Marsh.) that spread Dutch elm disease. Some encouraging results have been obtained (53).

In one study, an organic phosphate chemical "Amiton peratoluene sulfonate" (Chipman 6200), protected a mature elm when adjacent trees died of Dutch elm disease. All trees had been deliberately exposed to bark beetles emerging from infested elm wood placed on the ground beneath the trees. Translocation of the chemical in the tree has been demonstrated in laboratory tests. After 9 milliliters (2 grams) of the chemical were placed in the trunk of a 3-inch-diameter elm, beetles feeding on sample twigs were all killed within 44 hours. The lightest dosage to show effect was 3 milliliters (0.6 gram), which killed all the beetles present in 92 hours.

An extremely large dose (4 pounds or 1,814 grams) of the chemical was introduced into a larger tree (24 inches d.b.h.) with no adverse effects to the tree.

Improved methods of applying this chemical, better evaluation of needed safety factors, and more extensive field tests are needed before we can recommend use of this chemical to protect elm trees on a practical basis.

Chemical Control of European Pine Shoot Moth

Damage to red (*Pinus resinosa* Ait.) and Scotch (*Pinus sylvestris* L.) pine by the European pine shoot moth (*Rhyacionia buoliana* (Schiff.)) in recent years has increased in portions of the Central States. The problem has grown because of the increasing popularity of the two species for Christmas trees. The cumulative damage resulting from several years of infestation on red pine may render trees worthless for either timber or Christmas trees. Landowners can protect plantings by spraying with an insecticide or by clipping and destroying the infested tips. Both methods are expensive and as a rule are practiced only in smaller plantations. Neither is practical at the present time for large plantings.

Shoot moth damage can be reduced by drenching the trees with a dilute spray containing Derris root, lead arsenate, or DDT. But the high-gallage requirement of the dilute spray has discouraged most landowners from using this method except for high-value ornamental plantings.

The development of the air-blast type of sprayer or mist blower designed to apply concentrated sprays has decreased the average dosage required. Conventional hydraulic sprayers require 1,200 gallons per acre while only 40 gallons are required for the mist blower.

The results of DDT spray experiments we conducted from 1955 through 1957, indicate that the mist blower compares favorably with the hydraulic sprayer (dilute spray applications) for use in shoot moth control. A 6 percent DDT emulsifiable spray applied with the mist blower in the summer at the rate of 40 gallons per acre produced the best results. Timing of the treatments to coincide with egg hatching or the beginning of spring larval feeding is essential. Mist-blower applications were most effective in the summer and when an additional wetting agent was added to the standard 6percent DDT emulsion.

Ornamentals and small acreages may be treated with the heavier dosages of DDT with little danger, providing care is used. DDT is poisonous to humans as well as to fish and wildlife and should be handled with caution. The use of DDT over periods of 2 to 3 years in a plantation may produce undesirable side effects such as creating conditions favorable for infestations of mites, aphids, and scale. This research is incomplete and the results at this time should not be considered as recommendations. Those who are confronted with shoot moth damage should seek professional help in treating infested trees.

Reducing Damage by Red Oak Borers

One of the problems facing the hardwood-sawtimber grower in the Central States is the degrading of logs by the red oak borer (*Romaleum rufulum* (Hald.)) (fig.8). Damage is most severe in our upland oak type. Since cost of available direct chemical controls would be prohibitive, the best control is through cultural means that do not greatly interfere with existing management practices.

We began research this year to determine the latest possible date that timber stand improvement work could be done and still attain satisfactory mortality of the red oak borer larvae infesting the killed (poisoned, felled, or girdled) trees. It was anticipated that if the larvae had developed to the boring stage, killing the tree at that period would not prevent the insect from growing to maturity.

Because the red oak borer takes 2 years to complete its life cycle in the Central States Region, and because the adults appear in the odd-numbered years, the critical period for control occurs in the even-numbered years. Our research showed that killing trees later than mid-June of 1960, for example, would be of little value in reducing the borer population. Thus, the effective period for TSI would be when egg laying was complete, by August 1, 1961 (or odd-numbered years), to a time when larvae are entering the sapwood in mid-June, 1962 (or even-numbered years).

Figure 8.—Red oak borer damage is a serious cause of de-grade in oak logs and lumber.



Chlorotic Dwarf of White Pine

The symptoms of chlorotic dwarf disease of white pines (*Pinus strobus* L.) are premature defoliation, decreased plant growth, and stunted, chlorotic needles (17). Although the disease has been known for approximately 50 years, no causal agent has been found. Investigations were begun in 1957 to attempt to find the cause of this disease.

The use of organic chemicals as soil or foliage treatments on diseased plants did not improve their vigor. However, where fertilizer or lime were used as nutritional supplements, the declining annual growth, characteristic of chlorotic dwarf, was stopped and the plants partially recovered.

Some of the symptoms of chlorotic dwarf indicate that the disease may be caused by a virus. In 1958 side grafts were made on healthy 8-year-old white and Scotch pine with scions from diseased plants to see if this disease is transmissible (fig. 9). A high percentage of the grafts were successful but they have not demonstrated that a virus is involved. Moreover, diseased scions grafted on healthy white pines appear to be recovering. Healthy Scotch and white pine scions grafted on diseased pines retained their vigor and have not contracted the disease.

It has been generally believed that pines affected by chlorotic dwarf do not recover; however, 60 percent of 180 chlorotic dwarf plants in the Mohican State Forest, Ohio, originally checked in 1957, do appear to be recovering. Since such improvement has not been reported by other researchers, permanent plots were established in the Blue Rock, Mohican, and Zaleski State Forests in Ohio. Three hundred diseased plants have been rated for disease intensity and semi-annual inspections will be made over a 5-year period to evaluate any changes in their vigor.

Stem Canker of Yellow-Poplar

The results of a 3-year study of dying and disfigured yellow-poplars (*Liriodendron tulipiferas* L.) have shown the fungus *Fusarium solani* to be the primary causal agent. Results of monthly inoculations begun in 1958 have shown the organism to be most virulent during the fall months when tree growth has ceased. Inoculations made during other periods induced the disease, but the cankers usually became calloused within a few months. A number of infections created in September 1958, however, were still active in the fall of 1960 (fig. 10). Additional research is in progress to determine the susceptibility to this fungus of yellow-poplar trees growing on good and poor sites.



Figure 9.—Side graft typical of those used in chlorotic dwarf study.



*Figure 10.—Artificially induced canker caused by *Fusarium Solani* showing activity 2 years after inoculation.*

Oak Wilt Spread

Although root grafts may facilitate the spread of the oak wilt organism (*Ceratocystis fagacearum* (Bretz) Hunt), they occur too seldom to explain the amount of local spread observed in this region. Bark beetles have been considered one of the most likely carriers responsible, but it has not been shown that the fungus produces infecting material in insect galleries that could contaminate beetles.

To test this hypothesis, artificial galleries were made in the inner bark of oaks that were previously inoculated with oak wilt fungus. During the course of the experiment, about 1,000 galleries were examined and only three cases of active fungal growth were found.

FOREST MANAGEMENT

Obtaining and maintaining the highest productivity of our forest land is the basic purpose of timber management. This means growing the best quality timber in the greatest amounts in the shortest possible time. Our forest management research program is guided toward an understanding of the basic principles of forest growth and finding suitable methods of attaining the goal of maximum productivity.

Silvics

Soil-Site Relations Studied for Black Oak

We are continually searching for new, easy, accurate, and reliable methods of determining site index. One of the methods being tried is the correlation of site index with soil characteristics and soil types and series. The assumption is that specific characteristics peculiar to a soil type are closely related to site quality.

Soil-site studies of black oak (*Quercus velutina* Lam.) in Ohio, however, show that site index varies greatly within upland soil types as they are now described. This variation is so great that site quality cannot be estimated accurately using soil types alone. The greatest inaccuracies occur in estimating the very good or the very poor sites.

Site index is related to soil characteristics that may or may not be decisive in determining types or series in present soil classification. Depth of surface soil, subsoil texture, subsoil stone content, aspect, slope position, and slope steepness are related to site index but when used in soil classification are considered in only a general way. Present soil types need either added refinements in classification or derivation of phases to become reliable for determining oak site quality. This refinement would greatly increase the usefulness of soil surveys in forest management.

Tree Improvement

Interest in genetics and tree improvement is increasing rapidly. Results from some of our work in this field has been described previously (4, 33). A valuable reference was published: a bibliography of literature compiled from genetic and tree improvement papers and journals of the world (59).

Yellow-Poplar Seed Development

In cooperation with Southern Illinois University, we are trying to discover the possible causes of the very low (less than 15 percent) viability of yellow-poplar seed. So far, we have found that the living tissue in the seeds begins to deteriorate in mid-summer, leaving only a small number of filled, mature seeds. Microscopic observations reveal normal cell development from the time of pollination through development of the embryo; however, there is a low degree of fertilization by pollen on flowers of the same tree. Presently this incompatibility of the pollen is the only reason found for the low viability of the yellow-poplar seed. These results tend to agree with other findings; i.e., that pollination from other trees (and at some distance) increases the percentage of viable seed.

Cottonwood Fiber Length

Fiber length has been used for studies of environmental and genetic variability in cottonwood (*Populus* spp.) because long-fibered wood makes better pulp. Thirty-five thousand fibers from a total of 83 dominant trees were found to have an average length of 1.06 millimeters and ranged from 0.85 to 1.25 millimeters (5). In addition, we found that average length of fibers in a growth ring is correlated with the location of the ring on the tree. This means that fibers from the outer rings can be used to estimate accurately the length of fibers in the other rings.

Although fiber length is influenced by heredity, age and diameter of the tree were found to be most influential. The older and larger the tree, the longer the average fiber. These findings will enable us to screen out the better trees for reforestation.

A high percentage of long fibers can be obtained by using slabs and outer wood residues from sawlogs. By thinning young stands to increase diameter growth of residuals and holding crop trees until they are 25 to 30 years old, more long-fibered material can be obtained. Naturally the faster growing strains of cottonwood would produce harvest trees the quickest.

Natural Regeneration

Reproduction of Bottomland Hardwoods

Studies of bottomland hardwoods, an important segment of forests in the Central States, are continuing. We know that it is difficult to obtain natural regeneration of good species but too frequently we do not know why. An important step forward in bracketing some of these problems has been a comprehensive survey of reproduction by timber types and site

condition. Its purpose was to determine the status of tree reproduction and relate the reproduction of specific species and species groups to specific stand conditions and site factors.

Cottonwood and willow (*Salix* spp.), both intolerant species, grow in open, moist areas, where there is little or no litter. Other major species could not be as specifically connected with site or stand conditions. There is a tendency, however, for reproduction of elm, boxelder (*Acer negundo* L.), ash (*Fraxinus* spp.), silver maple (*A. saccharinum* L.), hackberry (*Celtis occidentalis* L.), oak, and hickory (*Carya* spp.), to be scarcer in areas where there is deep litter or dense ground vegetation. Successful development of the more intolerant species depends on proper release through overstory removal.

American elm (*Ulmus americana* L.), boxelder, green ash (*F. pennsylvanica* Marsh.), and silver maple are the most common species reproducing on bottomlands. On newly formed land, cottonwood and willow are most common.

Shortleaf Pine Seed Production

The effect of stand density on seed production in shortleaf pine has been studied and observed for some time. It is known that generally a decrease in density of fully stocked stands results in some increase in amount of seed produced. This is true of shortleaf pine stands in Missouri.

In a pine stand thinned to various densities in 1951, seed production increased as thinning was increased (table 6). Moreover, the greatest seed production was obtained when the stand was thinned selectively from below (leaving the larger dominant and codominant trees) and the hardwoods were removed from the stand. Naturally there were yearly fluctuations in amount of seed produced during the study (1954-1958) but none could be attributed to treatment.

In addition, we found that seed produced in the best years was of better quality, the criteria of quality being the number of filled seeds. Apparently conditions that favor high production also favor quality (filled) seed. We do not know, however, the extent to which the various treatments affected these conditions, if at all.

Seed Dispersal Patterns of Yellow-Poplar

In Indiana the pattern of seed fall of yellow-poplar has been traced for several selected seed trees (25). Being a light-seeded species, spread of these winged seeds is by wind. The rate of seed fall in Indiana is highest during the periods of high temperature or low rainfall. During

these periods the prevailing winds are usually from the south or southwest with localized variations due to topography and interrupted air currents.

The seeds in 1958 and 1959 were spread in an oval pattern with the long axis running north-northeast from the parent tree (fig. 11). As far as we know, 50,000 seeds per acre are sufficient to obtain ample stocking in spite of the extremely low viability of yellow-poplar seed. This amount of seed was found up to 350 feet north (downwind) and 150 feet south (upwind) of the seed trees. These distances could vary yearly according to wind velocities during the time of heavy seed fall.

In the area beyond 350 feet the seed fall diminished, but some seed was found as far away as 600 feet. Recent studies of yellow-poplar seed germination show that the seed may be stored in the litter for as long as 4 years before germination. This is significant in that successive seed crops of yellow-poplar seed, even though light individually, could build up to sufficient numbers of seed to adequately stock an area some distance from a seed source.

Other implications of this fact to forest management are also very important. Treatments to expose mineral soil could extend the area that can be regenerated naturally by isolated seed trees beyond 350 feet. Cutting practices could also be altered to take advantage of the prevailing winds, the anticipated areas of seed dispersal, and the ability of yellow-poplar seed to be dormant for extended periods before germinating.

Table 6.—Seed production of shortleaf pine stands thinned to different stand densities, 1954-58 (Thousand seeds per acre)

Residual basal area (sq. ft. per acre) ^{1/}	Seed production					Total
	1954	1955	1956	1957	1958	
50	39	58	341	820	7	1,265
70	12	14	124	578	5	733
90	14	16	48	362	2	442
110	5	18	60	214	2	299
138 (unthinned)	9	7	46	182	2	246

^{1/} In 1951, immediately after thinning.

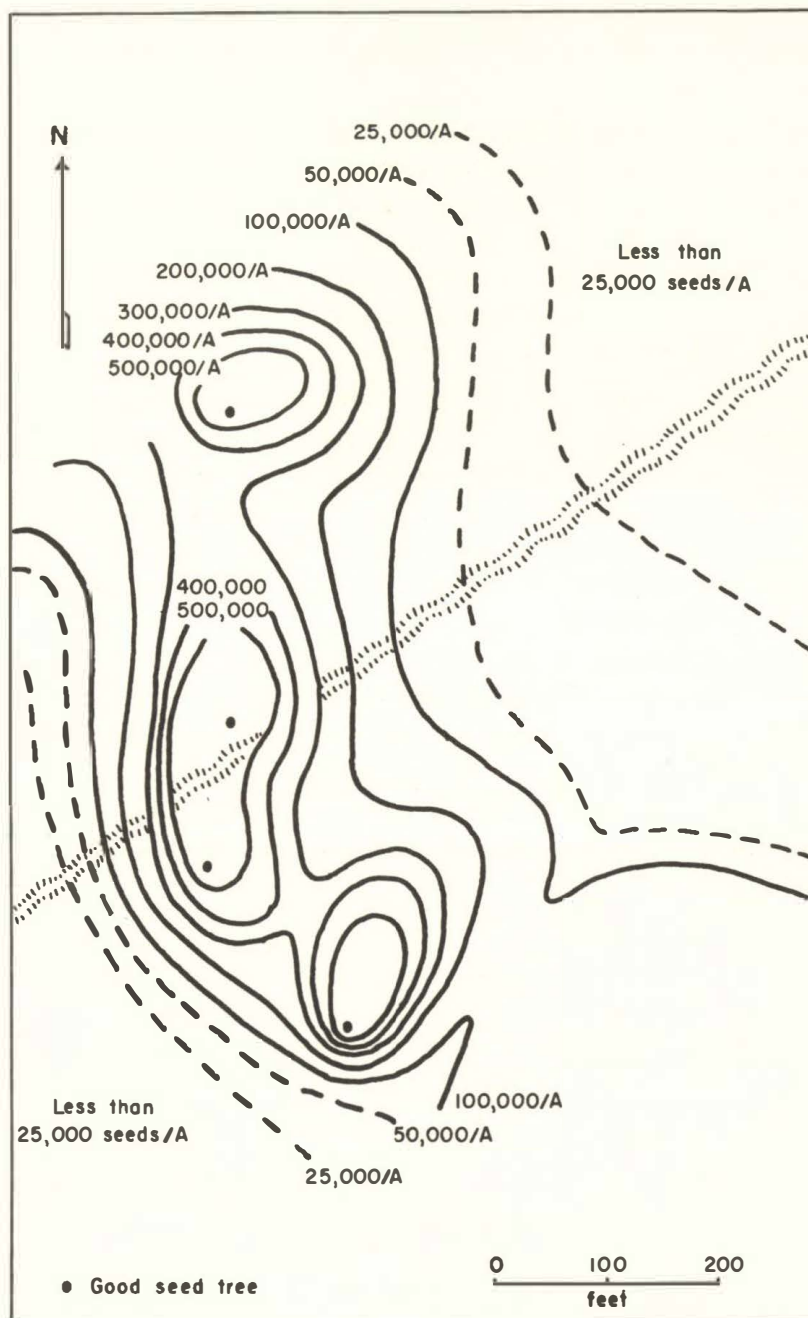


Figure 11.—Pattern of annual yellow-poplar seed fall on part of the study area showing lines of equal seeding density.



Figure 12.—Seed traps can be made inexpensively from bushel baskets.

Bushel Basket Seed Trap

In estimating seed abundance or in collecting seed for planting, "traps" sometimes are used. An economical trap made from a wooden bushel basket fastened to a post or stake, lined with unbleached muslin, and covered with chicken wire has been developed at our Columbia, Missouri office (fig. 12) (46). The chicken-wire mesh reduces pilfering of seed by rodents and keeps out a lot of the leaves and twigs that fall, and the muslin liner is used to help empty the basket without removing it from the support. The material required for each seed trap can be purchased for about one dollar.

Planting

Black Locust Not Always a Good Nurse Crop in Droughty Regions

Black locust grows rapidly and develops a massive root system at an early age. For these reasons, it has been widely used for many years as a soil stabilizer on highly erosive land. Its nitrogen-fixing characteristics have made it useful in many instances as a "nurse crop" when planted in association with other species, particularly on certain types of strip-mined land in areas of plentiful rainfall.

Black locust has been shown to be harmful, however, on some sites in southeast Kansas, where summer droughts are common. Because of its fast root development, black locust can take up more moisture than other species and soon overtops them. Moral: In areas with frequent summer droughts, do not use black locust.

Strip-Mine Forestation Research Summarized

A summary of more than 20 years' research in forestation of coal-stripped land has been assembled and published (34). It provides a technical guide for planning reclamation projects and points out important things to be considered, especially in forestation of such land (fig. 13).

Black Walnut Leaflet Revised

U.S.D.A. Leaflet No. 84 (1932), "Planting Black Walnut," has been revised. The new leaflet presents information gained through observation and research since the last leaflet was issued.

It covers the following essential steps to consider in planting and growing this species, especially for timber: Selecting the planting site, using pure or mixed plantings, choosing the planting stock (seedlings or nuts), where to get planting stock, preparing the ground, when to plant, care and handling of planting stock, how to plant, spacing of trees, early plantation care, and reference to other information sources.

Figure 13.—Experimental strip-mine plantings.



Table 7.—Relation between total and merchantable heights of shortleaf pine when top diameters are fixed and variable

D.b.h. (inches)	Merchantable height as a percent of total height				
	Fixed top diameter, inside bark			Variable top diameter, inside bark	
	3 inches	4 inches	5 inches		
	Percent	Percent	Percent	Inches	Percent
5	59	--	--	3.0	59
6	68	45	--	3.2	63
7	73	56	41	3.4	67
8	77	64	53	3.6	70
9	79	70	60	3.8	72
10	80	73	65	4.0	73
11	81	75	67	4.2	72
12	82	76	69	4.4	72
13	82	77	70	4.6	72
14	83	77	71	4.8	72
15	83	78	72	5.0	72

The percentages given in this table apply to the range of shortleaf pine sites in the Central States where total heights range from 30 to 75 feet. The table will serve as a guide for predicting future yield of products that depend on minimum top diameter and length, such as poles and posts.

Top characteristics of shortleaf pine, such as branching and live crown position, indicate that a variable top diameter represents a more realistic degree of utilization even where small products are cut.

PRODUCTS

Complete, efficient utilization of all timber is an important part of a comprehensive forestry program. New products and processes are increasing the demand for many previously unwanted species and creating new markets for low-grade materials. The effect is threefold: More usable wood is provided for current demands; returns to the processor and the timber grower are increased; and forest management opportunities are enhanced.

Felling and Bucking

A felling and bucking investigation relating the effect of crew size, chainsaw-type, tree species and size, topography, and volume cut on felling and bucking time and costs has been completed.

A one-man crew, regardless of type of saw used, was found to be more efficient than a two-man crew using one saw for felling, limbing, and bucking. The trees cut were medium sized and typical of those found in the upland hardwood forests of the Central States and adjoining areas. Volume cut per acre was nearly the same for both crews. Production varied from 8.3 to 9.8 thousand board feet of logs per 8-hour day for the one-man crew, while the two-man crew produced 9.7 to 11.2 thousand board feet per day—an advantage of only 14 to 17 percent for the two-man crew. On a production per man-day basis the balance was decidedly (almost 2 to 1) in favor of the one-man crew.

Without considering fixed costs, the gear-reduction-drive chainsaw proved more efficient than the direct-drive saw from the standpoint of production rate and cost of operation. Operation and maintenance costs for the gear-drive saw were 4.7 cents less than those of the direct-drive per thousand board feet cut.

Tree size had a significant effect on production time per thousand board feet. The smaller trees required more time per thousand board feet. The volume cut per acre had no significant effect on felling and bucking time per thousand board feet when trees of the same size were cut.

Saw type, topography, and tree species had no effect on production rates.

Length of Pulpwood Bolts

One-third more pulpwood can be recovered from tops left after harvesting hardwood sawlogs by cutting 4-foot instead of 7½-foot bolts. But the shorter lengths increase by about 2½ times the square feet of wood to be bucked and the number of bolts to be handled. Consequently, the increased costs for cutting and handling the 4-foot material may offset the added value of the increased volume that can be harvested in the shorter lengths (30).

These findings are based on measurements of the top residues from 60 upland-grown trees of seven hardwood species: White (*Quercus alba* L.), black, and scarlet (*Q. coccinea* Muenchh.) oaks, sycamore (*Platanus occidentalis* L.), hickory, elm, and yellow-poplar. Sawlogs to an 8-inch minimum diameter were cut from these trees. The remaining tops contained 986 cubic feet (825 pieces) if cut into 4-foot bolts and 737 cubic feet (311 pieces) if cut into 7½-foot lengths. The 7½-foot length was used arbitrarily because loads more than 8 feet wide are prohibited on some highways.

Diagraming Manual

A "Manual of Standard Procedures for Diagraming Hardwood Trees and Primary Products" was completed this year and will be issued for limited distribution. The manual describes surface and end defects normally found in hardwood trees and logs. It outlines procedures for measuring and recording the defects in a uniform manner. Developed at the request of the Forest Service National Log-Grade Committee, it will be used as a basis for future Forest Service hardwood log- and tree-grade studies.

Mechanical Feeding of Woodworking Machines

Our experience with power feeding versus hand feeding of a single-spindle shaper shows power feeding to be the best (19). We center-matched 57,000 linear feet of red oak sheathing material, in two thicknesses and three lengths, on the shaper. About half was fed by hand and the remainder with a power feeder. Use of the mechanical feeder increased production rate by 51 percent for 9/16-inch material and 83 percent for 1 5/16-inch stock. The thicker material was more difficult to feed by hand. The saving in man-hours per unit of production amounted to 34 percent for 9/16-inch stock and 45 percent on the 1 5/16-inch material.

Air Seasoning of Lumber

Our studies in the use of roofs for lumber piles during air seasoning of red oak and yellow-poplar were completed. The results indicate that the grade of lumber to be dried and cost of the roof are major factors in determining the economic advantages or disadvantages of using a roof on lumber piles. A roof costing as much as \$25 was found to return a profit by reducing degrade losses when used on most grades of red oak and yellow-poplar lumber (15, 26).

Tension Wood in Red Oak

In cooperation with the Forest Products Laboratory, we investigated the presence and effects of tension wood in red oak lumber used for furniture cuttings (32). About 10,000 board feet of 4/4, No. 1 Common, rough-sawn red oak boards were examined to select 3,200 board feet needed for the study. Tension wood was much more prevalent than anticipated. Approximately half the boards examined were identified as containing some tension wood. Further analysis showed that actually only 7 out of 440 boards selected for the study yielded cuttings entirely free of visible evidence of tension wood. About 82 percent of all cut material showed the presence of some of this abnormal wood.

Warping was found in only 6 percent of the cuttings identified as containing tension wood. Actually, there was a higher percentage of warping in cuttings considered free of tension wood. Consequently, tension wood apparently is not as serious a factor in causing warpage in red oak lumber as previously thought.

Since the source of the sample lumber was restricted to one sawmill in southern Illinois, the results of this study can be considered as fully applicable to red oak only from that particular geographical area. Red oak lumber from other areas may be substantially different, both as to frequency of occurrence of tension wood and its effect on warping.

RANGE

In the Missouri Ozarks 85 percent of the value of all farm products sold comes from livestock. Two-thirds of the woodland area is grazed, and native forage has been overgrazed to the point that the land is not producing at its full capacity. Our range research, centered in the Missouri Ozarks, is aimed at finding ways to judge and classify Ozark rangeland productivity, and to determine the best methods for increasing the forage resource in a manner compatible with other forest resource uses and needs of the people in the Ozarks.

Nutrient Quality of Ozark Forage

A sound range management program must be based on a realistic evaluation of the forage resource—its quality as well as its quantity. To learn more about the nutritive value of Ozark forage plants, samples of important species were collected in 1954, 1955, and 1956, and chemically analyzed. Samples were taken at various times during the years on several different forest and range sites.

Forest range.—On forest ranges, the protein content of most native grasses such as big bluestem (*Andropogon gerardi* Vitman), little bluestem (*Andropogon scoparius* Michx.) (fig. 15), Indiangrass (*Sorghastrum nutans* (L.) Nash.), and switchgrass (*Panicum virgatum* L.) falls below the minimum requirements for most cattle by mid-summer (fig. 16). But native legumes, such as tick-trefoil (*Desmodium* spp.) and bushclover (*Lespedeza* spp.), and other broadleaf plants, such as black-eyed susan (*Rudbeckia hirta* L.), remain high in protein until late summer. This extends the time during which cattle can get their daily protein requirements from forest range. The phosphorus content in forest range forage is more than adequate during the early growing season, but becomes deficient by late summer; calcium content is adequate all through the year.

Glade range.—Glade ranges in the Ozarks occupy a much smaller acreage than do forest ranges. They are, however, an important range type. Under proper management they can produce from 2,000 to 2,800 pounds (air-dry weight) of forage per acre per year. Glade forage has a slightly lower nutritive content than forest-range forage. The important forage grasses such as big bluestem, little bluestem, switchgrass, and baldgrass (*Sporobolus neglectus* Nash.) are all deficient in protein and phosphorus after mid-summer. Only calcium is adequate in glade forage all year. Glades generally have fewer desirable legumes and other broadleaf plants than do forest ranges.

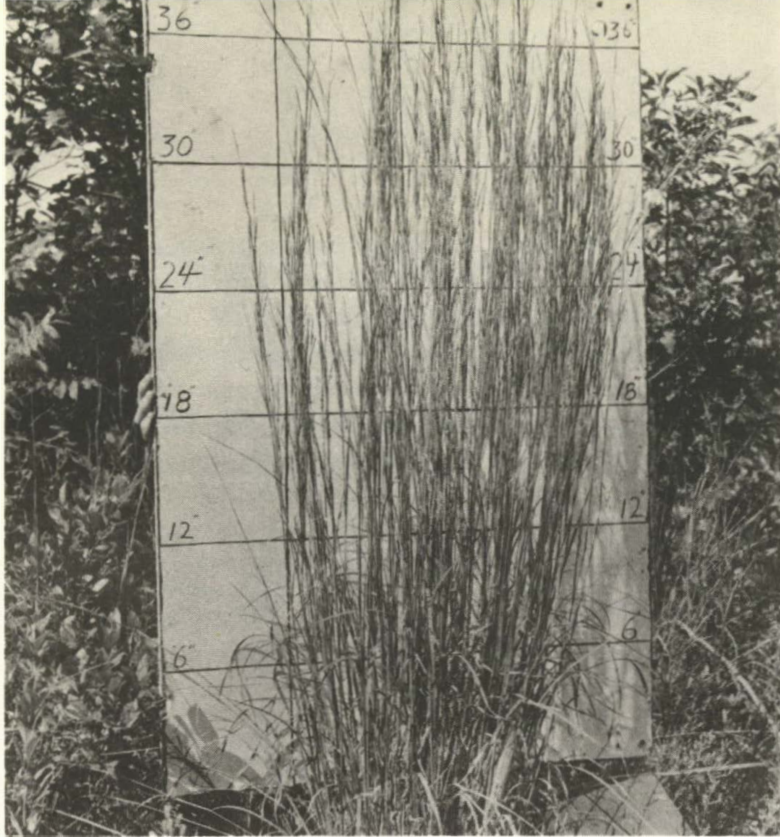


Figure 15.—Little blue-stem, a very desirable native grass in the Ozarks, frequently makes up more than half of the total herbage cover.



Figure 16.—Forage production in forest range may vary from more than 1,000 pounds of air-dry material per acre in an open stand such as this one, to less than 50 pounds of air-dry material under dense timber stands.

Old fields and pastures.—Seeded and fertilized stands of native grasses (such as big bluestem and switchgrass) or introduced grasses (such as orchardgrass (*Dactylis glomerata* L.) or fescue (*Festuca* spp.) in old fields and pastures contain sufficient protein, phosphorus, and calcium to meet the normal requirements of cattle. Orchardgrass and fescue are particularly high in protein and phosphorus. Furthermore, in the fall these species usually produce new growth which has a very high nutritive content.

Many Ozark forage species become low in certain nutrients by mid-summer. However, cattle on most Ozark ranches can obtain the minimum nutrient requirements much later in the season because of the variety of forage species and forage types, and because grazing stimulates new growth which is high in nutrients.

Forage Production on Timbered Range

Forage production on timbered ranges is inversely related to crown cover and basal area of the timber stand and to competition from weedy herbaceous plants. Our research has shown that, when thinning hardwood forests to obtain more forage, stands should be thinned to well below 50 percent crown cover (24). The increase in grass production was small as crown cover was reduced from 80 to 50 percent; however, as crown cover was decreased to below 50 percent, forage production increased rapidly.

Large increases in forage production also were obtained in heavily thinned pine stands. Here, total herbage production increased 4 to 5 times as basal area was decreased from 130 square feet to 70 square feet per acre. And in stands thinned to 50 square feet basal area it increased to more than 14 times the yield from unthinned stands.

The type of herbaceous vegetation that comes in when forest cover is reduced is influenced greatly by past use of the area. On areas where past grazing has been moderate or light and where desirable native plants have been retained, the forage increase is practically all in desirable grasses. In contrast, where overgrazing has reduced or eliminated the best native grasses, most of the increase is in weedy broadleaf plants. This supports a growing opinion among ranchers that to obtain good forage when reducing timber stand density on overgrazed areas, there are advantages to seeding an adapted grass, such as tall fescue, and fertilizing.

Grazed Glades Can Grow Good Grass

The glades, the Ozarks' only natural grassland (about 600,000 acres), have been over used by livestock for many years and forage production is far below what it could be (9). However, glade ranges recover very rapidly from abuse. In one of our range exclosures, for instance, herbage production jumped from about 400 pounds (oven-dry weight) per acre to 2,800 pounds per acre—a 600 percent increase—during 4 years of protection from grazing. In another exclosure, herbage production reached a peak after 5 or 6 years and then decreased. This decrease is typical of grassland where the old herbage is not harvested or removed periodically.

Complete range recovery probably would not be obtained with only 3 to 4 years of non-grazing. However, after this period, range improvement could continue under moderate grazing and without completely sacrificing current forage production.

WATER

Oftentimes water is a major product from forested areas and its quantity and quality reflect how these areas are managed. Watershed management research entails basic investigations of many biologic, ecologic, hydrologic, and erosional processes, but the ultimate aim is to integrate the knowledge obtained into the best possible multiple use management of the forest land.

Evaporation of Precipitation in a Hardwood Forest Area

Much of the rain that falls on a forest is evaporated before it ever becomes available for tree growth or streamflow. The total amount of water evaporated is greatly increased whenever the raindrops are intercepted either by live trees or by dead organic material lying on the ground.

The disposition of the rain that fell on a well-stocked, 40-year-old oak-hickory stand in Butler County, Missouri, was measured for 3 months in late summer. Of 10.84 inches of rainfall recorded 27 percent evaporated: 1.55 inches (14 percent) from the tree canopy and another 1.39 inches (13 percent) from the forest floor. Evaporation from the forest floor occurred in three stages: (1) Initial evaporation, 6 percent; (2) five to ten days after saturation, 4 percent; and (3) ten to twenty days after saturation, 3 percent.

The remaining 7.90 inches of rainfall (73 percent) percolated into the soil.

The oven-dry weight of organic materials on the forest floor averaged 4 tons per acre. Its decomposed fraction held more moisture on a volume-weight basis than did either the undecomposed leaf litter or the mineral soil.

Forest Plantation Development Influences Streamflow

A deep-rooted forest draws heavily on water in transit to streams. We found a decrease in water, as measured at a gaging station on a small Ohio watershed, after pines and some black locust were planted on abandoned land that had been farmed and grazed². Four streamflow attributes were analyzed in this study to determine changes in flow characteristics from when the trees were 1 to 6 years old (seedling period)

² We are indebted to the Agriculture Research Service, U.S. Department of Agriculture, Coshocton, Ohio, for the data analyzed here.

and when they were 13 to 17 years old (tree period). These characteristics were: (1) Flow depletion and storage, (2) the amounts of October-November flows, (3) flow frequencies, and (4) stormflow and baseflow components.

During the seedling period it took 30 days for growing-season streamflow to decrease from 4.5 to 0.01 c.s.m. (cubic feet per second per square mile); only 23 days were required to reduce streamflow to the same level during the tree period. The plantation decreased the combined October-November streamflow from 1.0 area-inch when the planting was 1 to 6 years old to 0.03 area-inch when 13 to 17 years old.

Under old-field conditions flow exceeded 0.01 c.s.m. 95 percent of the time. When the plantation was 12 to 15 years old the flow exceeded 0.01 c.s.m. only 55 percent of the time. During the 6-year seedling stage the stream was dry only 72 days, but during the 13- to 17-year tree stage it was dry 576 days.

There has been no real change in the proportion of total streamflow contributed by stormwater or groundwater (table 8). When the plantation was 13 to 17 years old, baseflow water yield still made up the major portion of total streamflow. However, the total streamflow has changed. Annual baseflow was reduced 4.5 inches and stormflow 1.2 inches in the tree stage. Seasonal reductions in volumes of stormflow and baseflow were greatest during the groundwater recharge period (October-December) and least during the period of maximum tree-growth activity (May-September).

Table 8.—Average periodic total, storm, and non-storm water yield

Hydrologic period	Yield in area-inches ^{1/}		
	Total	Stormflow	Non-stormflow
1939-44	14.44	2.97	11.47
1952-56	7.08	1.32	5.76
1939-56	11.10	2.22	8.88

^{1/} Inches of water over the entire watershed.

Twenty Years of Streamflow Records Show Benefit of Land Management

A 30,000-acre, hilly, farmed and forested watershed drains into the Muskingum Watershed Conservancy District reservoir that was created near Leesville, Ohio 20 years ago. The conservancy program for this watershed has included improving the farming methods (fig. 17) and planting pine on steep, eroded old fields. An analysis of this reservoir's water-level records for the period 1938-1958 shows that the improvement in farm and woodland management has helped reduce stormflow, particularly near the end of the 20-year period (52).

Considering only rainfalls of 1 inch or more in 24 hours, average stormflow per unit of rainfall was computed by relating reservoir rise to amount of rainfall. Over the period, average annual flows decreased slightly; fall and summer flows had greater decreases; winter flows declined most; and spring flows increased (fig. 18). Flows were reduced most for rainfalls of 1 to 2 inches and probably because of intensity, least for storms of 2 to 3 inches. No meaningful change was found in any season for storms above 3 inches.



Figure 17.—Good farming

. . . and good forestry



*help protect our water resource. (Photographs courtesy of Mus-
kingum Conservancy District.)*

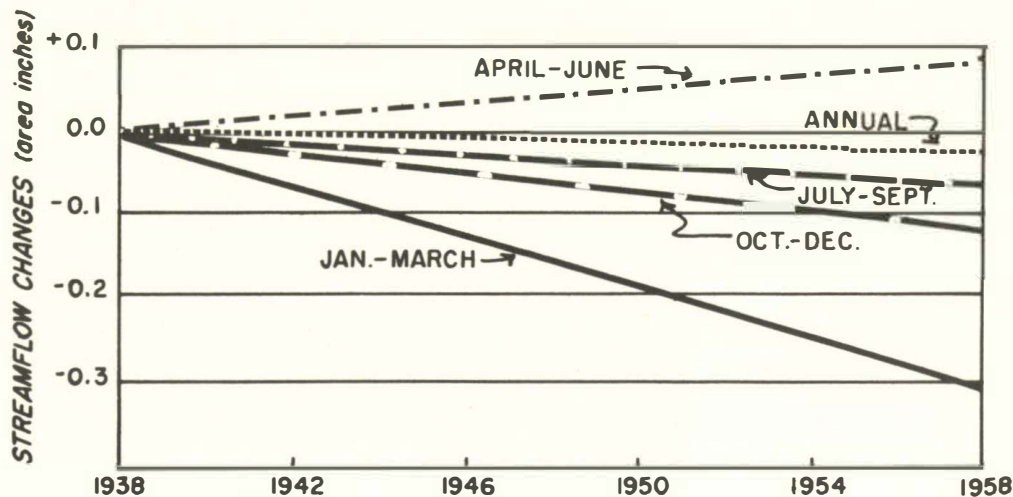


Figure 18.—Changes in average stormflows at Leesville reservoir for storms 1 inch and greater, 1938-1958.

The upward trend found for the April-through-June season may have been due to extremely heavy rains in June 1947 and April 1948 and an unusual ice storm in April 1957. Rainfall during the spring months is usually erratic, coming from winter-type frontal storms of long duration and low intensity and summer-type thunderstorms of short duration but high intensity. Usually soil moisture remains high in this period even though some water may be lost through evapotranspiration. This means that most of the precipitation runs off, either over or through the soil.

Summer rainfall comes as high-intensity, short-duration storms, but soil moisture is usually much less than in the spring. Hence, more of the rain can be stored in the soil and less goes to streamflow.

Heavy flood-producing precipitation ordinarily does not occur in fall and winter, but large flows may occur in winter even from well-managed areas if much rain falls on solidly frozen ground.

Soil type, geology, climate, topography, land use, and vegetative cover control the streamflow from a watershed. Throughout the 20-year period the last two of these have changed steadily on the Leesville watershed unit. It is reasonable to assume from our analysis that as more forest and open land is put under good management, stormflows will decrease, at least for the smaller storms.

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(Ozark forage is neither very rich nor very poor, but is adequate and can furnish cattle with the essential nutrients during most of the growing season.)
- (11) Carpenter, Roswell D.
 The possibilities of cooperative timber concentration yards—some difficulties involved in organization and operation. Report of Proc.: Conf. on Marketing and Utilization of Forest Products, Caldwell, Ohio, Dec. 4, 1959.
(Presents most of the "do's and don'ts" to be followed in organizing and operating cooperative timber concentration yards.)

- (12) Central States Station
1959 annual report. 97 pp., illus.
(Summarizes Station's work for 1959.)
- * (13) Central States Station
Forest Pest Observer. Vol. 4, No. 1.
(General survey of current forest insect and disease activity in the Central States Region.)
- (14) Champagne, E. G.
Trends and potentials in utilization of southeastern Ohio's hardwood forest products. Report of Proc.: Conf. on Marketing and Utilization of Forest Products, Caldwell, Ohio, Dec. 4, 1959.
(Discusses current and possible future uses of hardwoods for chemical, pulp, chip, veneered, laminated, and solid wood products. Stresses economic desirability of further processing lumber into a rough or finished product as compared with converting logs into lumber.)
- * (15) Clark, Wendell P., and Headlee, Thomas M.
It pays to roof your lumber. South. Lumberman 200(2492): 39-40, 44, illus.
(Shows savings that were realized from using roofs on piles of red oak and yellow-poplar lumber during air drying.)
- * (16) Crosby, John S.
Forest and range fire problems of the Missouri Ozarks. Misc. Release 32, 53 pp., illus.
(Lists and discusses the broad problems of fire control and the factors contributing to these problems in the Missouri Ozarks.)
- * (17) Dochinger, Leon S.
The occurrence of the chlorotic dwarf disease in some Ohio white pine plantations. Sta. Note 141, 2 pp.
(Of 43 white pine plantations in Ohio checked for symptoms of the chlorotic dwarf disease, 7 percent were found to be infected.)
- * (18) Donley, David E.
Field testing of insecticides for control of the Nantucket pine moth. Jour. Econ. Ent. 53(3): 365-367.
(Field tests during 1957 and 1958 showed that Delnav, Guthion, malathion, methyl perathion, and Trithion are as good or better than DDT for controlling the Nantucket pine moth and the European pine shoot moth.)

- * (19) Dunmire, Daniel E.
 Power feeding beats hand feeding. Hitchcock's Woodworking Digest 62(1): 63, illus.
(Use of a power feeder on a single spindle shaper increased production in a tongue and grooving operation by 50 to 83 per cent over hand feeding.)
- * (20) Ehrenreich, John H.
 Usable forage under pine stands? Sta. Note 142, 2 pp. illus.
(Total herbage yield increased more than 14 times as basal area of pine was decreased from 130 square feet to 50 square feet basal. There is enough forage in these low density pine stands to make grazing worthwhile.)
- * (21) Ehrenreich, John H., and Buttery, Robert F.
 Increasing forage on Ozark wooded range. Tech. Paper 177, 10 pp., illus.
(Spraying with 2,4,5-T, seeding to K-31 fescue, and fertilizing were very effective in increasing forage production.)
- * (22) Ehrenreich, John H., Buttery, Robert F., and Gehrke, Charles W.
 How good is Ozark forage? Univ. Mo. Agr. Expt. Sta. Bul. 759, 7 pp., illus.
(Although many Ozark forage species are low in certain nutrients by mid-summer, cattle on most Ozark ranches can obtain the minimum nutrient requirements much later because of (1) the variety of forage species and types and (2) high-nutrient content of forage regrowth.)
- * (23) Ehrenreich, John H., and Crosby, John S.
 Forage production on sprayed and burned areas in the Missouri Ozarks. Jour. Range Mangt. 13(2): 68-70., illus.
(Areas sprayed with 2,4,5-T produced more herbage than spring-burned areas; spring burning did not significantly increase total herbaceous yield.)
- * (24) Ehrenreich, John H., and Crosby, John S.
 Herbage production is related to hardwood crown cover. Jour. Forestry 58(7): 564-565., illus.
(The increase in grass production was small per unit reduction in crown cover from 80 to 50 percent, but with successive decreases from 50 percent crown cover to none there were relatively large increases in grass production.)

- * (25) Engle, LaMont G.
 Yellow-poplar seedfall patterns. Sta. Note 143, 2 pp., illus.
(The seed from individual yellow-poplar trees in Indiana fell in an oval pattern running north and south with the center lying north of the tree, coincidental with the prevailing winds. About 50,000 seeds per acre fell as far as 350 feet north and north-east of seed trees.)
- * (26) Headlee, Thomas M.
 Should I roof my lumber? Tech. Paper 171, 5 pp., illus.
(Discusses advantages of using roofs on piles of yellow-poplar lumber during air drying.)
- (27) Hosner, John F., and Minckler, Leon S.
 Hardwood reproduction in the river bottoms of southern Illinois. Forest Sci. 6(1): 67-77.
(A survey of bottomland types showed that there are usually enough seedlings of desirable species but they are often outnumbered by undesirable tree and shrubby species. Often, however, the better timber species tend to assert themselves by faster and more persistent growth.)
- * (28) Johnson, E. A., and Meginnis, H. G.
 Effect of altering forest vegetation on low flows of small streams. Internatl. Assoc. Sci. Hydrol., Helsinki. Extract of publication No. 51 of the IASH Com. of Surface Waters: 257-266.
(Cutting a mountain hardwood forest increased low flows of streams but low flows decreased after pines were planted on a small watershed. Streamflow increases declined with time as forest cover grew back on treated units.)
- (29) Johnson, E. A.
 Review of: Water facts for the Nation's future. By Walter Langbein and William C. Hoyt. Jour. Soil and Water Conserv. 15(1): 32-33.
(Book review.)
- * (30) Jokerst, Ronald W.
 Cutting short bolts means more wood—but more work, too. Sta. Note 144, 2 pp.
(By cutting 4-foot sticks rather than 7½-foot sticks, wood recovered from hardwood tree tops was increased 1/3 but work was increased 1½ times.)

- * (31) Krajicek, John E.
 Some factors affecting oak and black walnut reproduction. Ia. State Jour. Sci. 34(4): 631-634.
(Litter was found to be more detrimental than rodents to reproduction of four oak species whereas for black walnut the opposite was true. For all species few seedlings were produced unless the seeds were in the soil.)
- (32) Lassen, Laurence E., and Cooper, Glenn A.
 Significance of tension wood in furniture cuttings of red oak. U.S. Forest Prod. Lab. Rpt. No. 2193, 6 pp. plus tables and illus.
(Examination of furniture cuttings from red oak lumber from southern Illinois showed that warping associated with tension wood was not as serious as expected in this species.)
- (33) Limstrom, G. A.
 Current tree improvement research by the Central States Forest Experiment Station. First Cent. States Tree Impr. Conf. Proc., October 1959: 7-9, illus.
(Reports highlights of recent results in tree improvement research and describes current studies in this field.)
- * (34) Limstrom, G. A.
 Forestation of strip-mined land in the Central States. Agr. Handb. No. 166, illus.
(Tells where, when, and how tree planting should be done on strip-mined land and discusses site conditions that affect such planting.)
- (35) Loomis, Robert M.
 Even large trees are hurt by forest fires. The Ozarks Mountaineer 8(6): 9, illus.
(Top killing of small trees is usually conspicuous, but serious fire-caused injuries to the trunks of larger trees whose tops are not killed may go unnoticed.)
- * (36) Marston, Richard B.
 Calculating the percent moisture with a desk calculator by the use of negative numbers. Agron. Jour. 52(11): 670.
(Describes a method that facilitates the calculation of percent soil moisture of gravimetric samples through the use of negative numbers.)

- (37) Marston, R. B.
Review of: Soil moisture constants and their variation. By Walter M. Broadfoot and Hubert D. Burke. Jour. Soil and Water Conserv. 15(1): 31-32.
(Book review.)
- * (38) McCauley, Orris D.
Forest products prices in Ohio--1959. Tech. Paper 170, 14 pp., illus.
(Prices paid in Ohio for rough forest products in 1959 showed a general increase over prices paid in 1958.)
- * (39) Mendel, Joseph J.
Pulpwood production and consumption in the Central States-1959. Tech. Paper 174, 5 pp., illus.
(Pulpwood production and consumption continued to increase in the Central States in 1959; both reached a new record of more than 350,000 standard cords.)
- (40) Merz, Robert W.
Cull or defect? Jour. Forestry 58(5): 399-400.
(The terms "defect" and "cull", as defined in Forest Terminology, and their usage are discussed.)
- (41) Micklewright, James T.
How about hickory to sit on? Parks and Recreation 43(5): 256-257, 265.
(Preliminary tests show that hickory may be well suited for use as stadium seats.)
- (42) Minckler, Leon S.
Is timber marking a professional job? Jour. Forestry 58(6): 490.
(Expresses and discusses the view that, except for the simplest cases, timber marking is and should be a professional level job.)
- (43) Mitchell, Glen H., and Quigley, Kenneth L.
Retailing of Christmas trees in three selected Ohio markets. Ohio Agr. Expt. Sta. Res. Circ. 81, 17 pp.
(Describes Christmas-tree retailing practices.)
- (44) Neebe, David J., and Fletcher, Peter W.
Thinning of Eastern cottonwood in Missouri. Mo. Agr. Expt. Sta. Res. Bul. 733, 20 pp., illus.
(Describes the growth of 8-year-old natural and planted stands of cottonwood after thinning.)

- * (45) Phares, Robert E., and Liming, Franklin G.
 Comparative development of seeded and planted shortleaf pine on a forest site in the Missouri Ozarks. Jour. Forestry 58(12): 957-959, illus.
(Stocking and height growth of 1-year-old direct-seeded shortleaf pine are shown to be better than for planted trees of the same age.)
- * (46) Phares, Robert E., and Rogers, Nelson F.
 Bushel baskets make low cost seed and litter traps. Jour. Forestry 55(5): 398-399, illus.
(Describes how bushel baskets can be made into traps for collecting forest tree seed and litter.)
- (47) Quigley, K. L.
 Forest resources of Belmont, Guernsey, Monroe and Noble Counties, Ohio. Report of Proc.: Conf. on Marketing and Utilization of Forest Products, Caldwell, Ohio, Dec. 4, 1959.
(Describes forest resources and potential of four Ohio counties.)
- (48) Quigley, Kenneth L.
 Selling farm-grown pulpwood. The Ohio Farmer, Aug. 6, 1960, illus.
(Ohio pulpmills are buying 150,000 cords of locally grown wood each year and are paying nearly two million dollars for it. Small woodland owners can share in this expanding market.)
- (49) Ralston, Robert A.
 What a pulp and paper mill could mean to Missouri's forest economy. 6th Annual Air and Water Pollution Conf. Proc., Univ. Mo., Nov. 1960.
(Describes Missouri's forest resources and effects of pulpwood market on timber management practices.)
- (50) Rice, William W.
 A stacking jig produces better lumber packages. South. Lumberman 200(2491): 36, illus. Reprint of Sta. Note 131.
(A description of a lumber stacking jig for uniform stickering of lumber packages for air or kiln drying.)
- (51) Whipkey, Ronald Z.
 Annual water yields from small watersheds in the Ozarks. Hydrology workshop, Soil Conserv. Serv., Forest Serv., Soil and Water Conserv. Res. Div. of the Agr. Res. Serv., New Orleans, Oct. 24-27: 26.1-26.17, illus.
(Analyses of streamflow and precipitation records from three watersheds differing in size, cover and use showed the annual yield differences were largely in amounts of total baseflow.)

- * (52) Whipkey, R. Z.
Streamflow records show benefit of land treatment. Jour. Soil and Water Conserv. 15(6): 279-280, illus.
(Twenty years streamflow records show that forest management and soil conservation reduced downstream stormflows.)
- (53) Wollerman, E. H.
Dutch elm disease up to date. 15th Midwestern Shade Tree Conf. Proc., Omaha, Nebr.
(Dutch elm disease continues to threaten elms wherever they are grown. Best protection is to spray DDT emulsion and remove dying elms.)
- * (54) Worley, David P.
Local benefits from timber industry expansion. Tech. Paper 172, 17 pp.
(Every additional step in wood-products manufacture adds to the value of the product and hence to the profit that can be derived from it.)
- * (55) Worley, David P.
Recent developments stimulate hardwood lumber business in eastern Kentucky. Tech. Paper 176, 5 pp., illus.
(Expanded remanufacturing of lumber in the heavily forested areas of eastern Kentucky and the increasing use of trucks to move lumber and lumber products to market have benefited the economy of eastern Kentucky.)
- * (56) Worley, David P.
The small woodland owner in eastern Kentucky. Tech. Paper 175, 5 pp.
(One of the most important obstacles to forest management on small woodlands in Kentucky appears to be that owners are not aware of the income potential of their woodlands.)
- * (57) Worley, David P., and Dale, Martin E.
Recording tree defects in stereo. Tech. Paper 173, 11 pp., illus.
(Diagramming of trees is now commonly done in many timber management studies to record visible defects in study trees at the outset of an experiment so that any changes in tree quality may be accurately measured. Another describes a method of recording surface defects of trees through the use of stereo pairs of photographs.)

- (58) Wray, Robert D.
Ohio is site of new defense line in war to save our trees. The
Columbus Dispatch Magazine, Nov. 13, 1960: 38-40, 42, illus.
(Describes the new U.S. Department of Agriculture laboratories
at Delaware, Ohio.)
- * (59) Wright, Jonathan W., and Finn, Raymond F.
A bibliography on forest tree improvement, 1956-1957. U.S. Dept.
Agr. Misc. Pub. 808, 85 pp.
(A guide to material published on forest genetics in 1956 and
1957.)

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